STATE & PRIVATE FORESTRY
FOREST HEALTH PROTECTION
SOUTH SIERRA SHARED SERVICE AREA

Report No. SS14-01 March 11, 2014

To: Dean Gould, Forest Supervisor, Sierra National Forest
Ray Porter, District Ranger, High Sierra Ranger District

From: State and Private Forestry, Forest Health Protection, South Sierra Shared Service Area

Subject: **Bark beetle potential in the Aspen Fire, 2014**
High Sierra Ranger District, Sierra National Forest

The Aspen Fire (High Sierra ranger District, Sierra National Forest) burned from July 22, 2013 through August 8, 2013. Approximately 22,350 acres were affected in a mosaic of very low to high fire severities. The district plans for hazard removal along roadsides, recover the economic value of fire-affected trees, and re-establish forested conditions. Ramiro Rojas, District Silviculturist, requested Forest Health Protection to assess levels of burn intensity and determine potential for beetle infestation into project areas. This was not an individual tree marking exercise, but rather a landscape outlook to estimate whether high beetle infestation is probable given particular burn severities and other current environmental conditions.

Background

The Aspen Fire (High Sierra Ranger District, Sierra National Forest, California) started from a lightning strike on July 22, 2013, fully contained on August 8, 2013. Approximately 22,350 acres were burned in a mosaic of severities ranging from unburned to very low, low, moderate, and high severity. Twenty percent of the project area burned high severity with 90% tree mortality, 9% burned at moderate with 75% tree mortality, and 13% burned at moderate severity with 50% mortality. Over two-thirds of the burn areas were conifer forest types: Ponderosa pine-Jeffrey pine, Sierra Mixed conifer, conifer/oak, and red fir. The fire burned from the San Joaquin River canyon, east to the Kaiser Wilderness, and south towards the towns of Big Creek and Huntington Lake (Aspen Project, 2014).

The High Sierra Ranger District is currently developing the EA for the Aspen Recover and Reforestation Project to provide ecosystem restoration after to the Aspen Fire. The purpose of the project is provide safety for personnel and public, capture remaining forest product economic value, preserve and develop wildlife habitat, and reforest suitable portions (Aspen Project, 2014). The project area (22,350 acres) is located in all or portions of Township 6 South, Range 24 East; T7S, R24E; T8S, R24E; T6S, R25E; and TT7S, R25E of the Mt. Diablo Base Meridian. The silvicultural activities proposed are: hazard tree removal along roadsides, re-establish forested

conditions, and recover some economic value of fire-affected trees (Aspen Project, 2014). Forest Health Protection was requested to evaluate the potential of beetles subsequently infesting fire-damaged trees, causing additional mortality within the project area.

Ramiro Rojas (High Sierra Ranger District Silviculturist) and Beverly Bulaon (SSSA entomologist) visited a number of affected areas on January 23, 2014. They visited a variety of burn severities and assessed the amount of crown scorch on residual trees. Severely burned areas were simply blackened to gray ash; even the tallest trees in these areas were completely crown scorched. Since the current winter has been so mild in temperature and precipitation, bark beetle activity appeared to continue into late fall 2013, and was noted on several fire-killed pines (see Figure 1). No brood was observed. Looking across on the east face of Chiquito Ridge, multiple mortality pockets of ponderosa pines were easily visible. Many fully torched trees were easily assessed as road hazards (see Figure 2). They discussed potential die-off and survival on a number of injured trees, and the appropriate mortality probability (Pm) to use when cruising stands.

Figure 1. Western pine beetle pitch tubes noted on a fire-killed 12" ponderosa pine.

A long-term study conducted in California monitored several thousand trees affected by wildfires over a number of years, is the basis for the guidelines which help assess probability of tree mortality. Following Region 5, California fire-injured trees marking guidelines (Smith and Cluck 2011), the district plans to use a 70 percent probability of mortality (Pm) to make determination of trees most likely to die from fire injury on 1,835 acres areas where moderate to high severity fires occurred. This same 70% Pm would also occur on 3,238 acres where additional mortality is expected due to current drought conditions, bark beetles, and fire effects. A 70 percent Pm will be used for hazard trees outside of Northern goshawk and California spotted owl protected area corridors (PACs); 80% probability mortality for hazard trees within PACs. Hazard trees will be identified using the Region 5 Hazard Tree guidelines for Forest Service Facilities and Roads in the Pacific Southwest Region (Angwin et al. 2012). A 60% Pm will be used for trees >10 inches for roadside safety and hazard abatement. Tree removal is supported by Sierra Nevada Framework 2004 to promote healthy forests and economic stability of local communities (Aspen Project, 2014).

Figure 2. Dead ponderosa pines alongside a road, marked as hazard trees.

Understanding some characteristics of bark beetle host selection regardless of fire may help understand factors that insects utilize to determine hosts. The first three years post-fire, fire-weakened trees are the most susceptible to bark beetle attack (Breece et al. 2008). Land managers can gauge where bark beetles may be most active based on estimates where susceptible trees are found. Susceptible trees need to be: of suitable size, physiological condition, and in the case of fires, have certain degrees of crown scorch injury. These factors in combination are good guides that can help prioritize locations whether bark beetles may be attracted first. The burn intensity of an area can also provide a coarse estimate of the amount of crown scorch expected, but

field surveys improve accuracy of estimating injury. Regardless of insect infestation, Region 5 marking guidelines have determined the burn injury thresholds of varying tree species at which they would potentially expire.

Insect Biologies

Ponderosa pines in California are primarily attacked by western pine beetle (*Dendroctonus brevicomis* Hopkins, WPB). Western pine beetle prefer to attack weakened, diseased, or decadent trees, often killing in small groups (DeMars and Roettering 1982). They can attack diameters as low as six inches but will range up to very large diameter trees. Miller and Keen (1960) found western pine beetles in the Southern Sierras have at least three generations per year. Starting as early as April, there will be three peak flight periods in which beetles have the chance to attack. While this beetle is considered aggressive, it is often found in combination with other bark beetles when mass attacking trees.

Burned, scarred fire-injured trees are ideal for attack as their physiologically growth and defense mechanisms are weakened, reducing their ability to fend off incoming beetles. A recent study (Davis et al. 2012) found immediate WPB activity in burned areas (prescribed and wildfire) compared to other bark beetles in the Rocky Mountains; in prescribed burns, WPB activity comprised the majority of attacks. Research concur that western pine beetles appear to prefer trees with significant amounts of crown scorch (>80% average) (McHugh et al. 2003, Davis et al. 2012), and the greater proportion of trees with beetle attacks increased as total average site crown damage increased (Breece et al. 2008).

Mountain Pine beetle (*Dendroctonus ponderosae* Hopkins, MPB) and Jeffrey pine beetles (*Dendroctonus jeffreyii* Hopkins, JPB) are also host specific, associated mortality often increasing after several years of below normal precipitation. MPB prefers five-needled and lodgepole pines, but is occasionally found in smaller diameter ponderosa. Jeffrey pine beetle as the name implies, only attacks (large-diameter) Jeffrey pine. Both beetles will attack seemingly green healthy trees, but underlying preconditions like disease or water-stress usually reduce vigor and make trees susceptible. Strong negative correlations were noted when three years or more of below-normal water levels persisted, there were increases in bark beetle-associated mortality (Oblinger et al. 2011). According to Bradley and Tueller (2001), Jeffrey pine beetle activity is considerably higher on burned plots, often in conjunction with red turpentine beetle even with low prescription fires. In Southern California, a drought from 2002-2004 triggered widespread JPB mortality (Smith et al. 2009)

Fire-scorched trees are often immediately attacked by red turpentine beetle (*Dendroctonus valens* Hopkins, RTB) but their presence does not necessarily indicate mortality potential. This beetle prefers very thick bark; therefore primarily attacking the lower 8 feet of the bole of pines. Attacks often indicate of some tree stress or recent injury. High populations of this beetle can build up on the lower boles of burned trees, giving impression of eventual death. Direct mortality from RTB is very rare, but do predispose trees to other mortality agents. Site and drought conditions may also contribute to rate of decline, allowing RTB attacks to finish off trees (Ganz et al. 2003). Other burn factors need to be evaluated before RTB presence is included.

Other insects commonly called woodborers (ex: Family Buprestidae, Family Cerambycidae, Family Siricidae) also seek out fire-injured trees (Furniss and Carolin 1977). These insects are much bigger than bark beetles and prefer dead wood. They are found on sections of individual trees that may have been killed by bole scorch but avoid areas that still may be retaining moisture; their presence can be an indication where the cambium has

been killed by heat. Areas with deep bark char are often filled with the dust of woodborers. Due to the random nature of fire, woodborer presence on the bole can also be scattered and inconsistent.

Assessing potential of insect activity based on burn severity

Several factors help determine whether stands will likely be invaded by insects. While individual trees will have varying levels of damage, stands can be initially prioritized by burn severity. This may be very coarse, but helps narrow focus where surviving trees may be located. Burn intensity of individual tree crown is agreed to be the best predictor of post-fire mortality overall (Wallin et al. 2003, Schwiik et al. 2006, Breece et al. 2007). Factoring in bark char severity improves accuracy of assessments (Ganz et al. 2003). However, if large areas are blackened to the point of no needles or very minimal green needles remaining on trees, it can be indicative of high severity burns and low bark beetle attraction.

High-severity areas. Crown fire, long residence times, and severe vegetation loss are easy to see of areas that have experienced high intensity burns. Residual standing trees that fall under this category of "high-severity" are typically deeply charred with high scorch rates on the bole, crown, and root base. The research of the Region 5 guidelines found that trees in this category die quickly as the living cambial tissue is dead and dehydrated. Bark beetles prefer a certain level of phloem moisture for their offspring to be able to survive and complete development, which often takes a full year and highly scorched trees may not provide for the duration. Miller and Keen (1960) stated that WPB are not attracted to trees immediately killed by fire. They noted that this beetle selects trees with some green phloem and living buds – probably an indication that the tree may survive to the following year (Miller and Keen 1960). On the other hand, woodborers move deeper into the wood than bark beetles, preferring dead trees and drier conditions. Their development takes longer than bark beetles, emerging a few years after trees have already died. High severity areas are prime forage habitat for woodpeckers who seek out the larger-sized grubs of woodborers.

Moderate severity areas. According to the BARC map, moderately burned areas are adjacent or mingled with high severity patches. There are a fair number of acres considered moderate; however, basal area killed within these locations match up with high severity levels. With nearly a third of the basal area killed in these areas (>70%), it is not surprising that crown scorch kill is fairly high and die-off would be in the near future. Trees at this severity may be susceptible for bark beetle attack, but may also lose moisture faster than beetle brood finishes development. These areas would be the highest priority for action by land managers who are concerned about subsequent bark beetle after wildfire as these areas have high crown scorches and bole char. Miller and Keen (1960) accounted for 76% of dead trees three years post-fire to be caused by bark beetles attacking trees with 50-75% crown scorch (Northfork fire 1924, Sierra National Forest).

Low to very low severity areas. Residual trees found in low severity areas may still have green crowns and a higher potential for survival, but are still affected by fire. Defensive responses may not be adequate to pitch out attacking beetles as trees struggle to recover. Beetle attack success depends on reduced defensive capabilities of trees. Red turpentine beetles are often found at the base of trees after prescribed burns. Their presence can further weaken surviving trees, increasing their susceptibility to more aggressive bark beetles. McHugh et al. (2003) determined that burns of ponderosa pines starting with 30% crown scorch experienced mass attack more often than just partial attack. Miller and Keen (1960) still noted that WPB contributed to 7% of the mortality on trees with less than 25% crown scorch (Northfork fire 1924, Sierra National Forest).

Individual tree assessment. Intensity of crown scorch appears to be the best predictor for overall mortality, but also can infer potential beetle attack and success (McHugh et al. 2003, Wallin et al. 2003, Davis et al. 2012). Bark beetle selection was higher on severely crown scorched trees than low to moderately scorched (McHugh et al. 2003, Wallin et al. 2003, Breece et al. 2008). Determining bark char depth can assist in assessing whether cambium is alive or dead. Deep bark char may indicate dead cambium, where fire may have lingered for longer periods. Cambium damage inflicted from moderate or low intensity fires should not be discounted as it still may indicate places with injury. One thing to note, two species: *Abies* species (true firs) and *Ponderosa lambertiana* (sugar pine) both have higher rates of probable mortality at much lower scorch intensities (Stephens and Finney 2001). This was also confirmed by the Region 5 fire-marking guideline study (Smith and Cluck 2011). While no one variable or combination of variables accurately predicts trees to be attacked, crown scorch and bole injuries on most species give some indication of probable attack (Davis et al. 2012).

Discussion

While a fair number of trees are deemed susceptible within the Aspen Project, there is no guarantee that bark beetles will attack. However, the combination of prolonged drought and building neighboring populations, there is good expectation that bark beetle-associated mortality will be high this summer. During normal precipitation years where fire-injured trees may have been able to recover rapidly due to adequate winter snowpacks, this year may be dramatically different as drought-stressed trees have little reserve left for defense or recovery.

Current drought conditions in California have not been this severe since the 1970's. This winter 2013-2014 is recorded as the fourth driest year in the past four decades and is predicted to persist, according to the US Drought Monitor (February 10, 2014). As stated in the governor's weekly drought briefing (February 24, 2014), "Heavy rain and snow would have to fall throughout California very frequently from now until May to reach average annual rain and snowfall. Even with such precipitation, California would remain in drought conditions, due to low supplies from the two previous dry years." Water reservoirs have been at an all-time low, winter temperatures have been abnormally warm that mountain snowpack is melting faster. Forecasts for spring precipitation are meager, with cities in the state already slated to run out of water in the next two months. There are studies citing the correlation of lower-than-average precipitation years as triggers of bark beetle-caused mortality in the Sierras (Ferrell et al. 1994, Guarin and Taylor 2005, Oblinger et al. 2011). Since 2008, mortality associated with western pine beetle has been on the rise and has not appeared to have subsided, despite a few normal water years in 2010-2011. Also due to the drier and warmer than usual winter and summer temperatures, beetles have been flying earlier than their usual times but also longer into the season. As drier conditions worsen towards the end of the summer, tallies of beetle-attacked trees will probably increase.

Susceptible trees do not always equate to large beetle infestations; however, current bark beetle activity in the Sierra National Forest indicates there is a strong possibility for areas affected by the Aspen Fire. Sanchez-Martinez and Wagner (2001) found that while beetles fly long distances, there still need to be beetle populations within close proximity for high levels of mortality to occur. There is a critical level of beetles required to successfully mass attack even one tree. Breece et al. (2008) confirms this: their post-fire study in 2004-2006 was in the midst of a WPB outbreak in the Southwest, resulting in 96% of dead trees caused by subsequent bark beetle attack. Nonetheless, bark beetle mortality has been observed in multiple locations within and around the Aspen Fire for the past few years. According to 2012 and 2013 Forest Health Monitoring Aerial Detection surveys, numerous mortality pockets of western pine beetle and Jeffrey pine beetle building on

the eastern side of Chiquito Ridge (Bass Lake Ranger District). WPB has been very destructive in other areas of the district: infestations continue in Nutmeg Saddle, along Peterson Mill Road, and within the Big Creek watershed. Group mortality, as high as 60 to 100 trees, have been killed annually in these areas since 2009. Densely stocked pine plantations are primarily where the highest losses have been observed, but natural stands are also experiencing group die-offs of varying size classes. Bass Lake Ranger District to the north has been experiencing similar levels of ponderosa pine loss, in addition to legacy-sized sugar pines also being killed in high numbers (2012 & 2013 FHM Aerial Detection Surveys). Low elevations where ponderosa pines mingle with foothill brush ("front range") such Pilot Peak and Jerseydale (Bass Lake RD), are especially hard-hit with bark beetle mortality on-going since 2008 with little sign of abating. Large mountain pine beetle polygons were noted around Lookout Point and in sugar pines along Kaiser Creek. Jeffrey pine beetle-associated mortality in groups of seven trees per acre was located in 2013 near Coarsegrass Meadow (see Appendix B).

Selecting a 70% probability of mortality (Pm) in the Region 5 Fire-marking guidelines is a conservative mark. Yellow pines need percent crown *scorch* of at least 90% pre-bud break (at 70% Pm) to be considered dying within the short term. Post-bud break, this drops significantly down to around 60% crown *length killed* (yellow pines only) – a completely different variable that accounts for surviving branches that leaf out. The loss of photosynthesizing ability for residual trees to recover from fire injury is at risk for bark beetle infestation since a 30% crown scorch begins attracting WPB to some degree. For Jeffrey pines, fire injury alone already increases bark beetle attack probability by 25x (Bradley and Tueller 2001). Trees with more needle volume such as true firs and Douglas-firs still require at least 75% crown kill at 70% Pm. While higher Pm probabilities prevent taking trees that would otherwise survive, underlying prolonged stress by the current drought may cause more tree die-off than expected in normal years. The fir engraver (*Scolytus ventralis* LeConte) is most noted for this progressive build-up of activity after at least two consecutive years of drought (Ferrell 1974, Ferrell et al. 1994).

The first year after fire seems the most critical to conducting possible treatments to prevent beetle infestations or invite other pests; however, other benefits are also provided with areas that are not treated. McHugh et al. (2003) found that bark beetle and woodborer response was highest the first year following fire, with more than 50% of notable attacks found in burned areas. By the third year post-fire, attacks had dropped off significantly (McHugh et al. 2003). These first few years immediately after fire typically result in intense wildlife foraging as the insect population pulses with suitable material for brood laying – primarily woodborers in recently dead trees. Burned trees left on the landscape will be quickly infested by secondary insects and pathogens that accelerate decomposition and nutrient recycling, then become habitat or forage for other organisms. The use of Sporax™ (borate-based compound) is very prudent to prevent *Heterobasidion* root disease from infecting freshly cut stumps near campgrounds, permittee areas, and strategic roads.

Overcrowding and overstocked stands in California are considered high risk for insect attack (Oliver 1995) but stand density post-fire does not appear to factor into probable subsequent infestation except for Douglas fir. Overall crown scorch kill would be the best predictor for affected areas and individual trees. For unburned areas, high stand densities should still be a high concern as beetles are still highly attracted to stressed trees, whether from drought, resource competition, or other injury. There is no conclusive evidence (in California) that bark beetles migrate from burned to adjacent unburned areas (Sheri Smith and Danny Cluck, *personal communication*). Davis et al. (2012) noted fire-injured trees were not "sinks" for western pine beetles, but rather short-term spike of available hosts. Bark beetle populations that develop in burned areas do not appear to disperse to adjacent, unburned areas *during endemic years* (Davis et al. 2012). Therefore mortality that occurs in unburned areas is inherent of stand conditions not because of population spread. A project-level Risk

Map[1] of the Aspen Project shows high levels of risk that would be expected due to insects and diseases (see Appendix A).

If there are any questions or concerns regarding this report, please do not hesitate to contact us.

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[1] The Risk map is a model prediction to map risk within the next 15 years of 25% or more loss of the standing live basal area on trees greater than 1 inch in diameter due to insects and diseases (Forest Health Technology Enterprise Team 2007-06).

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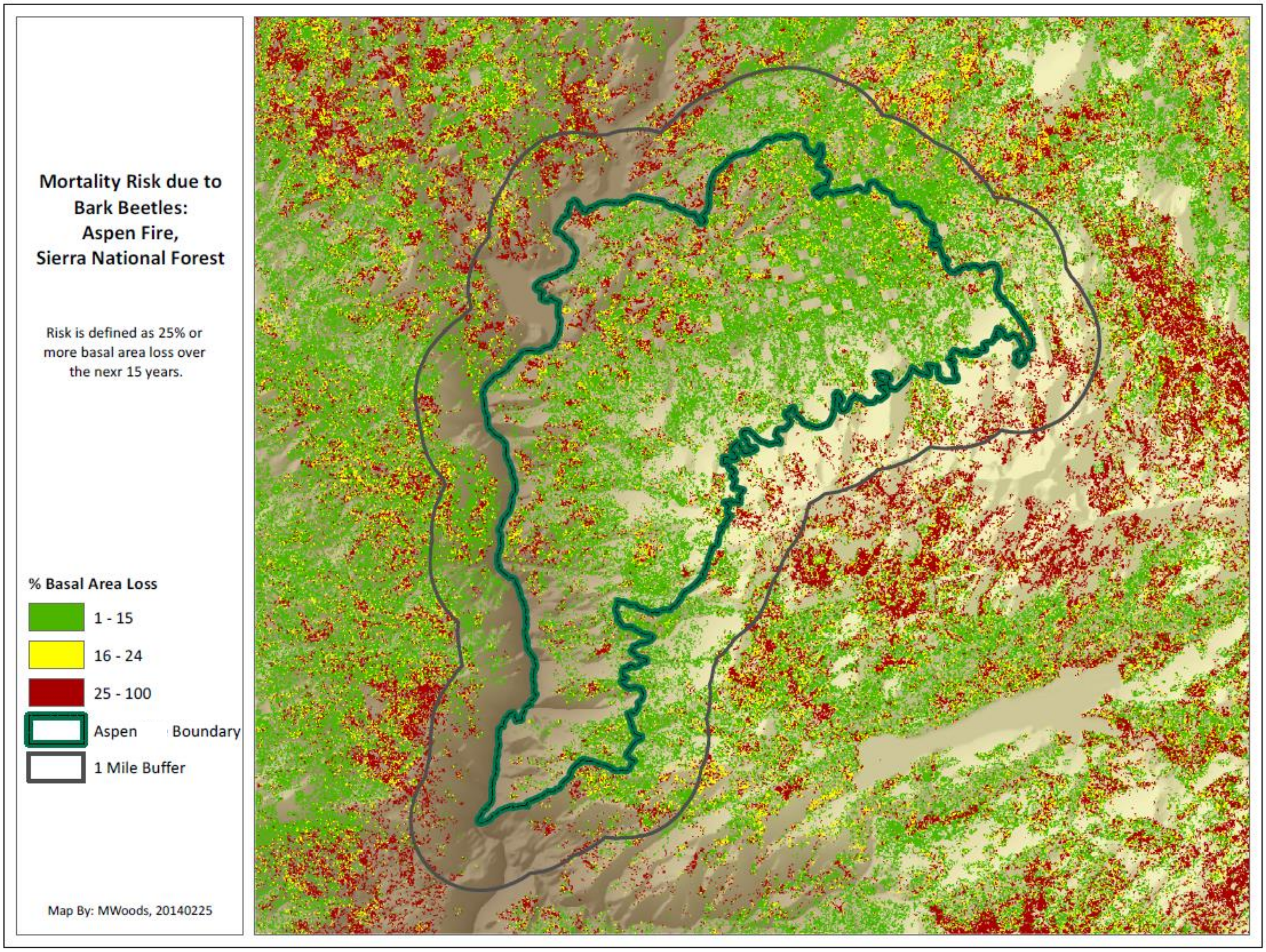
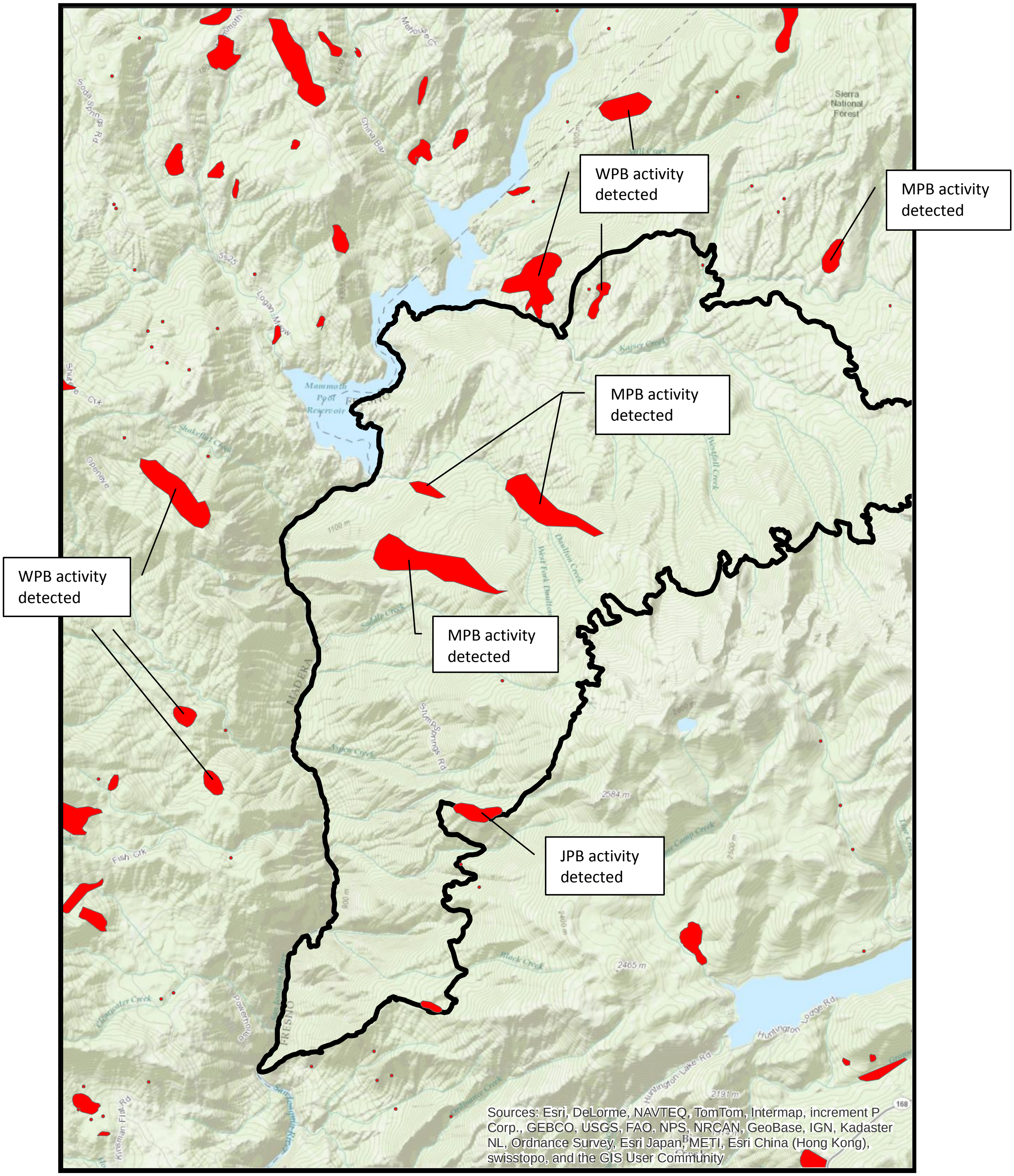


Appendix A. Forest Health Protection 2014 Risk map of the Apsen Project. Note heightened potential for loss due to bark beetles on the North and west faces of the project. *Correction: Green lines should say* ***Aspen Project Boundary***



Appendix B. An overlay of 2012 and 2013 Forest Health Monitoring Annual Aerial Detection Surveys depicting bark beetle-associated mortality within and near the Aspen Project (2013 Aspen Fire).

MPB = mountain pine beetle; WPB = western pine beetle; JPB = Jeffrey pine beetle.